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RESISTANCE OF TREES TO ICE STORM INJURY

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In a previous paper the writer* presented some data on the extent of accumulation of ice on trees during the glaze storm of 1922 in the Great Lakes region. Seeley† in Monthly Weather Review gives general estimates from various observers in Michigan on the amount of damage to trees. The present paper deals in a detailed way with the extent of injury to different species.

During the weeks following the storms examinations were made of over two thousand trees, representing nearly forty species. These grew within a ten mile radius of the northern end of Lake Winnebago, Wisconsin, and included trees of a variety of habitats such as city street, country roadside, river bank, farm woodlot, and swamp.

In the field the trees were listed in three divisions on the basis of size, the mature trees being designated as "large," the saplings as "small," and those of intermediate size as "medium." The trees in each division were classified on the basis of damage received, those having half or more of the crown broken being designated as "heavily damaged;" those having lost less than half the crown, but still badly injured, were indicated as having received "medium damage," while trees with no injuries at all, or with injuries no more severe than a broken branch or minor limb were placed in the column with the "slightly injured." Finally, trees which were permanently bent, but not broken, were noted. The results of the study are embodied in the table on the following page.

In making out the ranking of the species in the order of their resistance to storm injury, the figures of column 15 were added to those of column 14. This assumes that permanent bending is equivalent to at least medium damage.

* Rogers, Walter E.: Ice Storms and Trees. Torreya, 22: 61–63.

† Seeley, D. A.: The Great Glaze Storm of February 21–23, in Michigan. Monthly Weather Review, 50: 80–82.

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It will be noted that all fractions have been omitted from the columns.

	Large Trees				Medium Trees				Small Trees							
	Number of trees	% Heavily Damaged	% of Medium Damage	% Slightly Damaged	Number of trees	% Heavily Damaged	% of Medium Damage	% Slightly Damaged	Number of trees	% Heavily Damaged	% of Medium Damage	% Slightly Damaged	Total Number of Trees	% Seriously Damaged (Heavy & Medium)	% Permanently Bent	Rank in Resistance
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
Acer Negundo	6	66	33	0	9	11	44	44	40	25	10	65	55	45	0	17
Acer sp.*	13	46	23	30	77	28	37	18	9	11	33	33	99	64	13	26
Acer platanoides**	—	—	—	—	—	—	—	—	4	0	0	100	4	0	0	—
Acer saccharum	1	0	100	0	49	12	36	51	25	12	20	68	75	44	0	16
Alnus incana	—	—	—	—	18	33	50	0	—	—	—	—	18	83	16	28
Amelanchier canadensis	—	—	—	—	5	0	0	100	—	—	—	—	5	0	0	—
Betula alba	—	—	—	—	39	48	10	35	7	42	0	57	46	54	0	18
Betula lutea	—	—	—	—	26	23	19	57	37	8	0	91	63	22	0	12
Carpinus caroliniana	—	—	—	—	19	0	10	89	12	8	0	83	31	9	3	6
Carya ovata	6	0	0	100	63	11	15	73	22	0	0	100	91	19	0	10
Catalpa speciosa	—	—	—	—	14	0	7	92	22	0	0	100	36	2	0	1
Celtis occidentalis	1	0	0	100	18	27	22	11	6	0	16	33	25	40	40	27
Crataegus sp.	9	11	11	77	14	0	14	85	1	0	0	100	24	16	0	8
Fagus grandifolia	—	—	—	—	27	3	70	25	16	37	12	50	43	65	0	21
Fraxinus americana	4	50	25	25	54	11	18	70	28	10	0	89	86	25	0	13
Fraxinus nigra	7	42	42	14	127	21	17	43	20	20	15	45	154	40	17	19
Gleditsia triacanthos	5	0	0	100	2	0	0	0	—	—	—	—	7	0	0	—
Juglans cinerea	1	0	0	100	30	6	26	66	5	0	0	100	36	27	0	14
Ostrya virginiana	—	—	—	—	45	13	11	75	34	2	2	94	79	16	0	7
Picea abies	—	—	—	—	56	3	0	96	2	0	0	100	58	3	0	2
Populus alba	1	0	100	0	5	0	0	100	—	—	—	—	6	16	0	—
Populus balsamifera	—	—	—	—	9	0	22	77	—	—	—	—	9	22	0	—
Populus deltoides	8	16	33	0	90	64	25	6	1	0	0	0	99	89	4	31
Populus grandidentata	6	0	100	0	90	11	53	33	20	0	0	50	116	55	10	20
Populus nigra italica	—	—	—	—	3	100	0	0	—	—	—	—	3	100	0	—
Populus tremuloides	12	66	16	0	27	51	22	14	89	20	1	12	128	36	50	29
Prunus pennsylvanica	—	—	—	—	9	77	0	22	1	0	0	100	10	70	0	22
Prunus serotina	—	—	—	—	8	0	37	62	—	—	—	—	8	37	0	—
Prunus virginiana	—	—	—	—	5	0	0	60	5	20	0	60	10	10	33	15
Quercus alba	4	0	0	100	78	1	8	89	7	0	0	100	89	8	0	4
Quercus bicolor	—	—	—	—	22	0	9	90	2	0	0	100	24	8	0	5
Quercus macrocarpa	18	16	5	77	6	0	33	66	11	0	0	100	35	17	0	9
Quercus rubra	9	0	33	66	91	2	17	86	10	0	10	90	110	20	0	11
Robinia pseudacacia	—	—	—	—	6	66	16	16	8	62	0	37	14	71	0	24
Thuja occidentalis	—	—	—	—	4	75	0	25	149	3	1	95	153	6	0	3
Tilia americana	14	42	42	14	78	18	55	26	19	21	31	47	111	71	0	23
Ulmus americana	24	54	33	12	51	49	27	23	16	31	37	31	91	76	0	25
Ulmus fulva	—	—	—	—	12	25	33	16	3	33	0	0	15	53	33	30

*Acer rubrum and A. saccharinum. It was impossible, while the ice was on, to distinguish between the two species.

** In ranking the species, those of which less than ten individuals were examined were omitted.

The ten most resistant species in the order of their resistance were the following: *Catalpa speciosa*, *Picea abies*, *Thuja occidentalis*, *Quercus alba*, *Quercus bicolor*, *Carpinus caroliniana*, *Ostrya virginiana*, *Crataegus sp.*, *Quercus macrocarpa*, *Carya ovata*. This is in marked contrast with the findings of Illick* after a

* Illick, J. S.: A Destructive Snow and Ice Storm. Forest Leaves, XV: 103-107.

Pennsylvania storm, where *Carya* ranked first in resistance. *Ulmus*, *Betula* and *Fraxinus* which rank second, third and fourth respectively in Illick's list do not appear among our first ten at all.

Among the factors which make for resistance to ice storm injury the following appear to be of considerable importance.

1. Small surface exposure. Trees with few stout twigs fared better, on the whole, than those with many fine twigs. The first place held by *Catalpa* was due largely to this factor.

SHAGBARK HICKORY. Typical of conditions in farm woodlots

2. Shortness of limb. The longer the branch, the greater the leverage which the weight of ice could bring to bear on the part. A comparison of column 12 with columns 8 and 4 shows that almost invariably small trees were damaged less than larger ones of the same species. While other factors are involved here, shortness of limb played a strong part.

3. Horizontal branching. The accumulations of ice on the horizontal branches of the spruce, etc., soon changed from a bending load to a pulling load, and this was easily carried so long as the weight was symmetrically distributed. The elms and

some of the poplars were at the other extreme as regards this factor, and suffered very severely. Attention is called to the fact that *Ulmus americana* ranked twenty-fifth, and *Populus deltoides* thirty-first, the last on the list.

4. Flexibility of stem. The *Thujas* and *Ostryas* which exhibited a high degree of resistance were in many cases bent into

AMERICAN ELM. Typical of conditions in city streets.

semicircular arches for days after the storm, yet very few were broken, and all the others righted themselves after the ice melted.

5. Strength of materials. High resistance of the oaks was due largely to this factor, the limbs of the oak having, in general, neither great flexibility, favorable angle nor reduced surface. Indeed many of the oaks bore great numbers of leaves during the storm period and the ice accumulated on these as well as on the stems.

It might be added that some species were favored in many cases by some form of external support. For instance, *Carpinus* often was found leaning its ice loaded branches on other plants growing beside it, while the low branching *Crataegus* rested its weight on the ground.

Without question the effects of injury will be apparent in the storm area for decades to come. Ashe,* writing from the viewpoint of a forest inspector, states that in the Appalachian forests he has noted deformities of trees which he ascribes to ice storms of a hundred years previous. Ice storm injuries will also pave the way for fungus and insect attacks, and the damage from these secondary causes will in time probably equal that from the original injuries.

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THE DIRECT ASSIMILATION OF FREE NITROGEN BY PLANTS

A review of recent work on the subject

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In May, 1909, at the International Chemical Congress, which took place in London, I presented a paper by my collaborator, Prof. G. Pollacci and myself, entitled: "Sull'assimilazione dell' azoto atmosferico libero nei vegetali superiori," in which we gave the first results obtained from analysis of carefully prepared cultures of various phanerogamous plants grown under sterile conditions and free from combined nitrogen. From our experiments we conclude that the faculty to assimilate free nitrogen from the air is not, as stated in all books on vegetable physiology, peculiar to some microorganisms without chlorophyll, as these analyses demonstrated that there are also phanerogamous plants that can assimilate that element without being in symbiosis with bacteria.

In January of 1911, we published the complete work (1) on the direct assimilation of the nitrogen in plants, having in two years of research extended the experiments and analyses to other plants, such as green algae, lichens, mosses, aquatic hydropter-

*Ashe, W. W.: Note on "Ice Storms in The Southern Appalachians" by Verne Rhoades. Monthly Weather Review, 46: 374.